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None

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H3T
H3Q

(54) **Frequency changer**

(57) A frequency changer used in a high-frequency oscillator that includes a tuning circuit and at least one auxiliary coil (13) has a semiconductor switching element (6) serving as an electronic switch. This electronic switch is connected between the higher potential side of the main tuning coil (12) included in the tuning circuit and one end of the auxiliary coil (13), the other end of which is connected to the lower potential side of the main tuning coil (12).

Fig.4

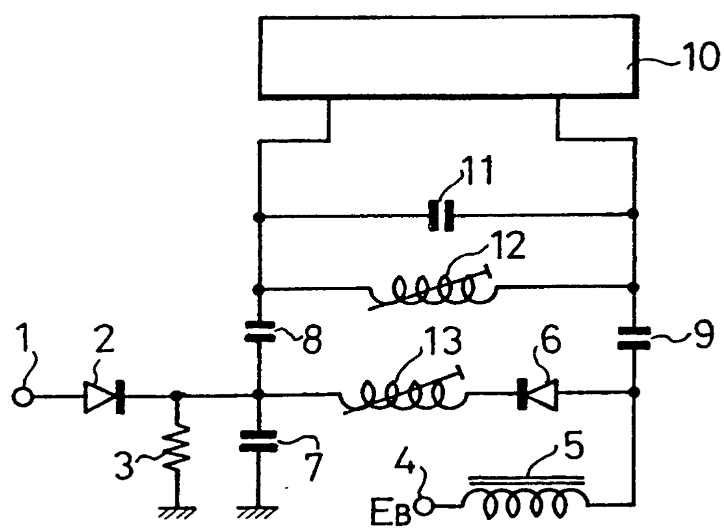

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Fig. 1

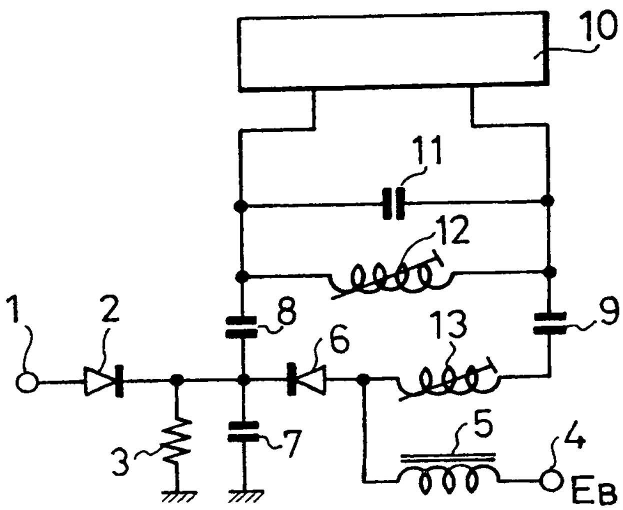

Fig. 2

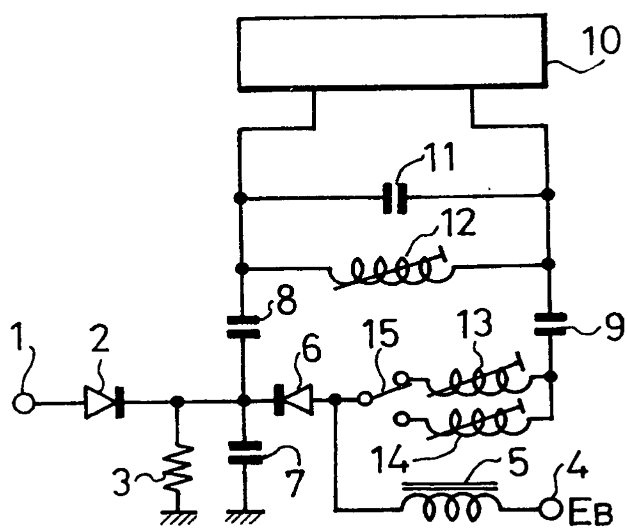

Fig. 3

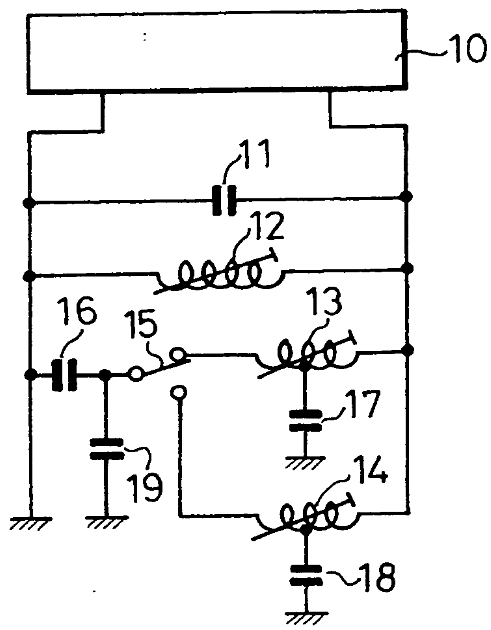

Fig. 4

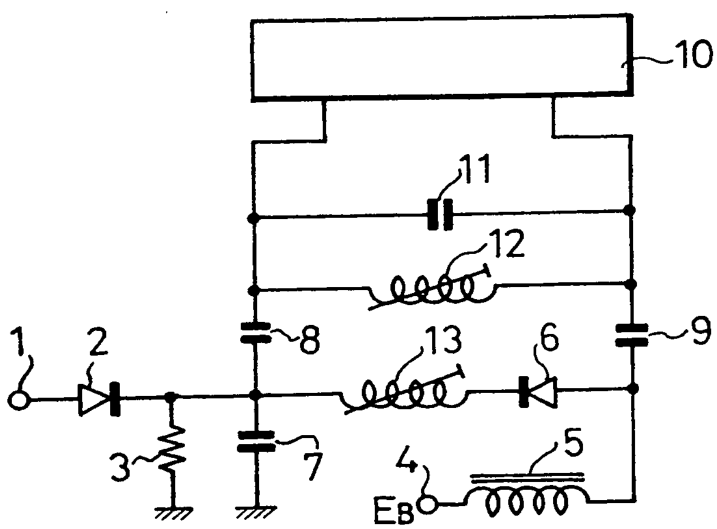

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Fig. 5

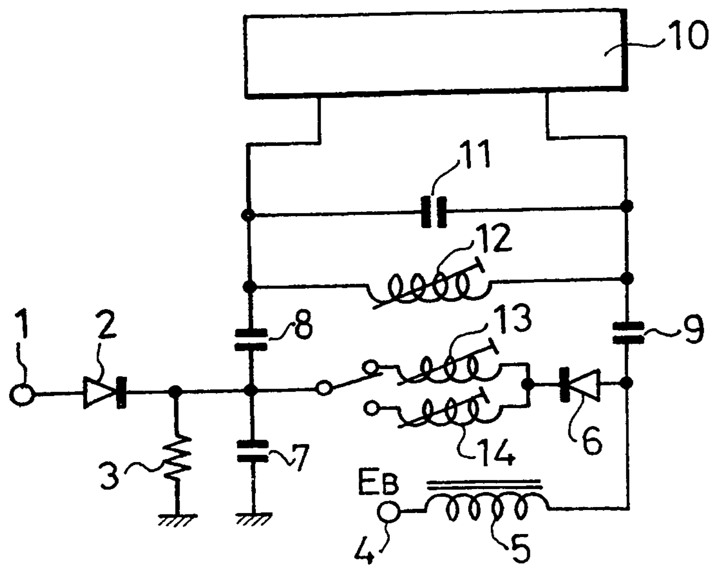
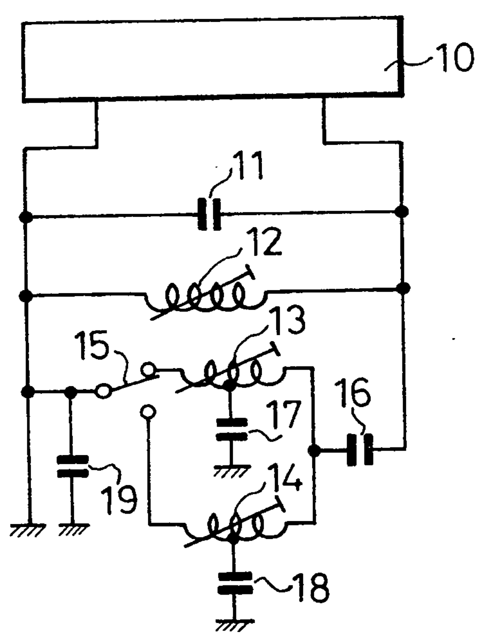


Fig. 6



SPECIFICATION

Frequency changer

Field of the invention

The present invention relates to a frequency changer and, more particularly, to a frequency changer which is used in a high-frequency oscillator capable of producing two or more frequencies, for changing the inductance of the tuning circuit from one value to another by the use of an electronic switch.

Background of the invention

A conventional circuit configuration including an electronic switch to change the oscillation frequency of a high-frequency oscillator from one value to another is shown in Figure 1, where the circuit includes a power supply terminal 1 to which an electric power is fed for frequency conversion, a diode 2 for preventing the passage of an electric current in the reverse direction, a bias-setting resistor 3, a terminal 4 to which a fixed electric power is supplied for switching a diode 6 between two states, a choke coil 5 for preventing the passage of high-frequency signals, the aforementioned semiconductor switching element 6, such as a diode, serving as an electronic switch, a bypass capacitor 7, capacitors 8 and 9 for preventing the passage of direct current, an oscillating element 10, such as a transistor, a tuning capacitor 11, a main tuning coil 12, and a tuning coil 13.

When the voltage for changing the oscillation frequency is not applied to the terminal 1, a fixed voltage E_B applied to the terminal 4 biases the diode 6 serving as the electronic switch in the forward direction, causing the diode to conduct. Thus, the diode 6 allows high-frequency signals to pass through it, and therefore the tuning coils 12 and 13 are connected in parallel. The combination of the two inductances is the inductance of the tuning circuit and determines the oscillation frequency.

When the voltage applied to the terminal 1 for frequency conversion is higher than the voltage E_B applied to the terminal 4, the diode 6 is reverse biased and hence this electronic switch 6 is in off condition. Therefore, the tuning coil 13 is isolated from the tuning circuit and so the inductance of the tuning circuit that determines the oscillation frequency only consists of the inductance of the main tuning coil 12.

Referring next to Figure 2, there is shown another conventional circuit which is similar to the circuit of Figure 1 except that a mechanical switch 15 is added to increase the number of frequencies that can be oscillated by one and that another tuning coil 14 is introduced.

The circuit of Figure 2 operates exactly in the same way as the circuit of Figure 1. When the diode 6 acting as the electronic switch is conducting, by connecting the additional switch 15 to the side of the coil 14, the main tuning coil 12 is connected in parallel to the coil 14, so that the oscillation frequency is changed to a different value.

When the voltage applied to the terminal 1 is higher than the fixed voltage E_B applied to the terminal 4, the diode 6 is off as described in connection with Figure 1, and therefore the coils 13 and 14 are isolated from the tuning circuit whether the contact of the switch 15 is connected with the coil 13 or the coil 14. Hence, the oscillation frequency is made independent of the position of the contact of the switch 15. Where the oscillation frequency is sufficiently low, this relationship is established. Where it is high, however, the above relationship does not hold, and the oscillation frequency varies according to the position of the contact of the switch 15.

The circuit of Figure 2 was applied to the sound carrier oscillator of an RF modulator for use in a VTR set that can be used for various types of television transmission standards. Measurements were made of this configuration as follows.

The diode 6 serving as the electronic switch was first biased off, and the mechanical switch 15 was connected with the tuning coil 13. Under these conditions, the main tuning coil 12 was tuned to the oscillation frequency of the sound carrier according to the NTSC standards, i.e. 4,500.0 KHz. Then, the diode 6 was biased on, and the coil 13 was tuned to the oscillation frequency of the sound carrier according to the PAL system, i.e. 5,500.0 KHz. Thereafter, the mechanical switch 15 was made contact with the side of the tuning coil 14, which was then tuned to the frequency of the sound carrier according to the PAL system, i.e. 6,000.0 KHz. Subsequently, the diode 6 was turned off. Measurement showed that the oscillation frequency for the sound carrier according to the NTSC standards assumed undesirable values ranging from 4,497 to 4,498 KHz. When the contact of the mechanical switch 15 was made contact with the side of the coil 13, the oscillation frequency for the sound carrier according to the NTSC standards was 4,500.0 KHz. That is, in spite of the condition that the diode 6 was biased off to isolate the tuning coils 13 and 14, a difference of 2 to 3 KHz was introduced depending on the position of the contact of the switch 15, thus presenting a problem in practical applications.

One of the main causes of the difference in the oscillation frequency that was made between the positions of the contact of the mechanical switch 15 is that there exists a capacitance of several pF between the electrodes even when the electronic switch 6 is not conducting. Another cause is that the inductances of the tuning coils 13 and 14 are not identical. A still other cause is that stray capacitances of differing values exit between the coil 13 and the shielding case and between the coil 14 and the case, respectively.

More specifically, referring further to Figure 2, the cathode of the diode 6 is grounded through the bypass capacitor 7 and hence is at zero potential for high frequencies. The anode of the diode 6 which is at a higher potential is connected with the switch 15 and the tuning coils 13, 14. Consequently, the stray capacitances existing between ground and each of the switch 15 and the coils 13, 14 as well as the stray capacitance in the diode 6 are inserted in parallel with the tuning circuit consisting of the tuning

capacitor 11 and the main tuning coil 12. For high frequencies the cpacitors 8 and 9 acting to prevent the passage of direct current are negligible and so when the electronic switch 6 is biased off, the circuit of Figure 2 can be represented by an equivalent circuit shown in Figure 3 as far as high frequencies are concerned.

Referring next to Figure 3, the components indicated by reference numerals 10 through 15 correspond to those indicated by the same reference numerals in Figure 2. When the diode 6 is not conducting, a stray capacitance 16 exists between the anode and the cathode. A stray capacitance 17 exits between the tuning coil 13 and ground. Another stray capacitance 18 exits between the tuning coil 14 and ground. Existing between the switch 15 and ground is a stray capacitance 19.

The same measurements were made of the circuit shown in Figure 3 as the foregoing. In particular, the diode 6 was connected in parallel to the main tuning capacitor 11, and the capacitor 11 was tuned to the frequency of the sound carrier, i.e. 4,500.0 KHz. The combination of the stray capacitances 17, 18, 19 and the stray capacitance 16 in the diode 6 was designated Cx. Then, the electronic switch 6 was biased on, and the tuning coils 13 and 14 were tuned to 5,500.0 KHz and 6,000.0 KHz, respectively. Subsequently, the switch 15 was made contact with the side of the coil 13. Under these conditions, the combination of the stray capacitances 17, 18, 19 and 16 was Cx $\pm\Delta$Cx, where ΔCx was the sum of the changes in the stray capacitances 17 and 18 when the coils 13 and 14 connected in parallel to each other were adjusted. As previously mentioned, when the contact of the switch 15 was shifted from the side of the coil 14 to the side of the coil 13, a change of 2 to 3 KHz in the oscillation frequency was introduced. This phenomenon is accounted for by ΔCx, the sum of the changes in the stray capacitances 17 and 18. This combined capacitance is usually of the order of several pF, and the changes in the stray capacitances which are produced when the coils 13 and 14 are adjusted are combined. This combined capacitance affects the oscillation frequency. As such, ΔCx cannot be neglected.

Summary of the invention

It is the main object of the present invention to provide a frequency changer which is free of the foregoing difficulties.

It is a more specific and related object of the invention to provide a frequency changer which has a diode acting as an electronic switch and inserted into the circuit at a positin different from that in the prior-art device so as to be less affected by changes in the stray capacitances that are caused by adjusting the tuning coils inserted in parallel to the main tuning coil during a conversion of frequency.

Brief description of the drawings

Figure 1 is a circuit diagram of a conventional circuit configuration using an electronic switch to change the oscillation frequency from one value to another;

Figure 2 is a circuit diagram of another conventional circuit configuration which has a mechanical switch in addition to the components of Figure 1 to increase the number of frequencies that can be oscillated by one;

Figure 3 is a diagram of an equivalent circuit of the circuit of Figure 2 for high frequencies;

Figure 4 is a circuit diagram of a frequency changer according to the present invention, corresponding to the circuit of Figure 1;

Figure 5 is a circuit diagram of another frequency changer according to the invention. corresponding to the circuit of Figure 2; and

Figure 6 is a diagram of an equivalent circuit of the circuit of Figure 5 for high frequencies when the diode acting as an electronic switch is biased off.

Detailed description of the invention

Frequency changers according to the present invention are shown in Figures 4 and 5, and they correspond to the circuit configurations of Figures 1 and 2, respectively. An equivalent circuit of the configuration of Figure 5 for high frequencies in the condition that the diode acting as an electronic switch is biased off is shown in Figure 6. The configurations of Figures 4 and 5 are similar in structure to those of Figures 1 and 2, respectively, except that the diode 6 is inserted at different positions. However, the former configurations differ from the latter in a strict sense. That is, equivalent circuits of the former for high frequencies differ from the latter.

More specifically, in each of these novel frequency changers, the diode 6 is connected to the higher potential side. Therefore, when the electronic switch 6 is biased off, the equivalent circuits shown in Figures 5 and 6 can be obtained. Namely, the bypass capacitor 7 allows the passage of high frequencies. This causes the stray capacitance 16 in the diode 6 to be connected in series with a parallel circuit formed by the stray capacitances 17, 18 and 19. This series circuit consisting of the capacitance 16 and the parallel circuit is connected in parallel to the main tuning capacitor 11.

Now let C_Y be the capacitance of the series circuit, or combined capacitance, of the stray capacitance in the diode 6 and the parallel circuit formed by the stray capacitances 17, 18, 19 when the oscillation frequency is tuned to the aforementioned 4,500.0 KHz of the sound carrier. The diode 6 is biased on, and then the tuning coils 13 and 14 are tuned to 5,500.0 KHz and 6,000.0 KHz, respectively, according to the foregoing procedure. Subsequently, the contact of the switch 15 is again made contact with the side of the tuning coil 13 as shown in Figure 6. Under these conditions, the series combination of the stray capacitance 16 in the diode 6 and the parallel circuit of the stray capacitances 17, 18, 19 is equal to $C_Y \pm \Delta C_Y$, where ΔC_Y is the sum of the changes in the stray capacitances which are caused when the coils 13 and 14 are adjusted.

The stray capacitance 16 in the diode 6 is of the order of 1 pF, while the combined capacitance of the stray capacitances 17, 18 and 19 is several pF. Consequently, the capacitance of the series circuit which is formed by the stray capacitance 16 in the

diode 6 and the parallel circuit of the capacitances 17-19 is always less than the capacitance of the diode 6 of approximately 1 pF. In this way, the small capacitance 16 predominates in the capacitance of the series circuit formed by the stray capacitance 16 in the diode 6 and the parallel circuit of the stray capacitances 17-19. Thus, even when the stray capacitances in the tuning coils 13 and 14 change, the change in the capacitance of the series circuit is much smaller. Therefore, the capacitance of the series circuit which is inserted in parallel to the tuning circuit consisting of the capacitor 11 and the coil 12 has intrinsically a quite small value of less than 1 pF. In addition, the effect of the sum ΔC_Y of the changes in the stray capacitances in the coils 13 and 14 which are caused by tuning operation is minimal.

The change in the oscillation frequency which was caused by biasing on or off the diode 6 in the circuit configuration shown in Figure 5 was actually measured in the same manner as the aforementioned measurements. The obtained values ranged from 0.15 to 0.2 KHz, which are below those of the configuration of Figure 2 by a factor of ten to twenty. In this fashion, by arranging the diode 6 serving as the electronic switch on the higher voltage side, a quite excellent frequency changer has been achieved.

Although an RF modulator has been cited by way of an example in the description thus far made, the invention is not limited to the conversion of frequency in such modulator, but rather the invention can be applied to all high-frequency oscillators which employ both an electronic switch and a mechanical switch to change the oscillation frequency from one value to another.

As hereinbefore described, the invention provides a frequency changer used in a high-frequency oscillator and in which the semiconductor switching element is connected to the higher potential side of the main tuning coil and causes the auxiliary tuning coils to be inserted in parallel to the main tuning coil to change the value of the inductance. Consequently, the configuration is less affected by the stray capacitances in the auxiliary tuning coils than the prior-art configuration and hence it can stably perform its frequency conversion.

CLAIMS

1. A frequency changer for use in a high-frequency oscillator having a tuning circuit, a main tuning coil included in the tuning circuit, at least one auxiliary coil that is adapted to be connected in parallel to or disconnected from the main tuning coil such that the oscillator can produce two or more frequencies, said frequency changer comprising:

a means for connecting one end of the auxiliary coil to the lower potential side of the main tuning coil,

a semiconductor switching element serving as an electronic switch that connects the auxiliary coil in parallel to the main tuning coil or disconnects the auxiliary coil from the main tuning coil, one end of the switching element being connected to the other end of the auxiliary coil,

a means for connecting the other end of the switching element to the higher potential side of the main tuning coil,

the semiconductor switching element being controlled so as to insert the auxiliary coil in parallel to the main tuning coil of the tuning circuit or disconnect the auxiliary coil from the main coil to change the inductance of the tuning circuit from one value to another, whereby changing the oscillation frequency of the oscillator from one value to another.

2. A frequency changer as set forth in claim 1, further comprising a diode placed between the lower potential side of the main tuning coil and a power supply terminal to which an electric power for frequency conversion is fed.

3. A frequency changer as set forth in claim 1, wherein said at least one auxiliary coil is a plurality of coils which are connected in parallel relation to each other between the lower potential side of the main tuning coil and the semiconductor switching element, and wherein a switch is placed between the lower potential side of the main coil and the semiconductor switching element.

4. A frequency changer as set forth in claim 3, wherein a capacitor is placed between ground and the junction point of the plurality of coils connected in parallel.

5. A frequency changer substantially as hereinbefore described, with reference to Figures 4 to 6 of the accompanying drawings.

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